Origin of Magic Angles in Moiré Graphene Superlattices

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Recently, the correlated (Mott) insulation and seemingly unconventional superconductivity was observed in Moiré flat-band graphene superlattices at the first "magic angle" [1,2]. Twisted Bilayer Graphenes (TBG) are known to host the isolated, relatively flat bands near charge neutrality by being tuned at the set of the so-called magic angles. In this talk, based on our recent study [3], we propose an enhanced continuum model for TBG which has the absolutely flat bands at an infinite set of magic angles θ and the main band gap is also maximized. The remarkable properties of our model shows the origin of the magic angles, revealing a surprising periodicity in terms of $\alpha \propto 1/\theta$, where magic angles are "quantized" with steps $\Delta\alpha \cong 3/2$.We prove analytically that the vanishing of the Dirac velocity ensures the exact flatness of the band and thus we connect the absolutely flat bands origin to the emergent zeros of the BA-stacking wave function exactly at the magic angles. Using perturbation theory up to the eighth order, we capture important features of the first-magic-angle physics, which precisely follows our numerical results. We further claim a theoretical proposal for the realistic second magic angle in TBG where the superconductivity may also occur. Some unpublished results will be also discussed [4].

Refs:

[1] Cao et al., "Unconventional Superconductivity in Magic-Angle Graphene Superlattices," Nature, v 556, 43-50 (2018)

[2] Cao et al., "Correlated Insulator Behaviour at Half-Filling in Magic Angle Graphene Superlattices," Nature, v. 556, 80-84 (2018)

[3] Tarnopolsky, Kruchkov, Vishwanath, "Origin of Magic Angles in Twisted Bilayer Graphene, arXiv preprint 1808.05250, (2018)

[3] Kruchkov et al., manuscript in preparation, (2018)